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(54) SOLDER BUMP FABRICATION METHOD AND SOLDER BUMPS FORMED THEREBY

VERFAHREN ZUM HERSTELLEN VON LÖTHÖCKERN UND LÖTHÖCKER SO HERGESTELLT.

PROCEDE DE FABRICATION DE PERLES DE SOUDURE ET PERLES DE SOUDURE FORMEES A L'AIDE DUDIT PROCEDE

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(56) References cited:
EP-A- 0 313 082 **US-A- 4 950 623**

- **IEEE Transactions on Components, Hybrids, and Manufacturing Technology, Vol 14, No 3, September 1991, Edward K Yung et al., "Electroplated Solder Joints for Flip-Chip Applications", pp. 549-559, see page 550 col. 1 line 7 - line 31, page 551 col. 1 line 11 - page 552 col. 1 line 39, page 555 col. 2 line 45 - page 556 col. 2 line 53; see fig. 1**

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Description

This invention relates to microelectronic device manufacturing methods and more particularly to methods of forming electrical and mechanical connections for a microelectronic substrate, and the connections so formed.

High performance microelectronic devices often use solder balls or solder bumps for electrical interconnection to other microelectronic devices. For example, a very large scale integration (VLSI) chip may be electrically connected to a circuit board or other next level packaging substrate using solder balls or solder bumps. This connection technology is also referred to as "Controlled Collapse Chip Connection - C4" or "flip-chip" technology, and will be referred to herein as "solder bumps".

In the original solder bump technology developed by IBM, the solder bumps are formed by evaporation through openings in a shadow mask which is clamped to an integrated circuit wafer. Solder bump technology based on an electroplating process has also been actively pursued, as, for example, described in Edward K. Yung & Iwona Turlik, "Electroplated Solder Joints For Flip-Chip Applications," IEEE Trans. Comp. Hybrids & Man. Tech., Vol. 14, No. 3, September 1991. Electroplated solder bumps are typically used in integrated circuit chips requiring a large number of connections. In the electroplating process, an "under-bump metallurgy" (UBM) is deposited on a microelectronic substrate having contact pads thereon, usually by evaporation or sputtering. A continuous under-bump metallurgy film is typically provided on the pads and on the substrate between the pads, in order to allow current flow during solder plating.
Alternatively, a plating base composed of a material that is not wettable by solder (e.g., chromium) may be deposited across the contact pads and the substrate between contact pads, with individual pads of under-bump metallurgy deposited on top of the chromium film over the contact pads.

In order to define the sites for solder bump formation over the contact pads, the sites of the solder bumps are photolithographically patterned, by depositing a thick layer of photoresist on the under-bump metallurgy and patterning the photoresist to expose the under-bump metallurgy over the contact pads. Solder pads are then formed on the exposed areas of the under-bump metallurgy, over the contact pads, by pattern electroplating. The plated solder accumulates in the cavities of the photoresist, over the contact pads. Then, the under-bump metallurgy between the plated solder pads is etched, using the solder as an etch mask, to break the electrical connection between the solder bumps. The photolithographic patterning and under-bump metallurgy etching steps define the geometry of the under-bump metallurgy at the base of the solder bump, between the solder bump and the contact pad. Solder bump fabrication methods are described in our US-A-4,950,623; US-A-4,940,181 to Juskey, Jr et al; and US-A-4,763,829 to Sherry.

Unfortunately, in fabricating solder bumps using the process described above, it is difficult to preserve the base of the solder bump, at the contact pad. Preservation of the base is important because the base of the solder bump is designed to seal the contact pad. The process described above often reduces the base, which exposes the underlying contact pad and leads to mechanical and/or electrical failure.

The base may be reduced due to at least two steps in the above described process. First, there is often an inherent distortion of the patterned thick film photoresist layer, and misalignment with respect to the contact pads lying thereunder. Typically, a dry thick film photoresist (such as du Pont RISTON® photoresist) or multiple coatings of liquid photoresist is used, in order to accumulate sufficient volume of plated solder. Thicknesses on the order of tens of microns (for example 50 micrometers) are used. The thick film photoresist must be accurately patterned over the contact pads, without misalignment or distortion.

Unfortunately, for dry film photoresist, distortion of the shape of bump sites may result from the relatively poor adhesion of the photoresist to the smooth under-bump metallurgy. Light scattering through the thick film photoresist and cover layer, and the imprecise nature of the thick film photoresist development process, also contribute to distortion of the photoresist mask pattern over the contact pads. For multiple-layer liquid photoresist, factors such as hardening of photoresist due to long periods of baking, and edge bead build-up, may cause distortion in the photoresist mask pattern over the contact pads. Accordingly, the resultant solder bump often does not cover the entire contact pad.

The second major factor which may reduce the solder bump base is undercutting during chemical etching of the under-bump metallurgy. In particular, as described above, the under-bump metallurgy is typically etched, between the solder bumps, in order to break the electrical connections therebetween. In order to insure that all of the unwanted under-bump metallurgy is removed, overetching typically needs to be practiced, because etching frequently does not proceed uniformly across the substrate surface. However, this overetching typically undercuts the under-bump metallurgy between the solder bump and the contact pad, which reduces the solder bump base. Electrical and mechanical reliability of the solder bump connection is thereby degraded.

It is therefore an object of the present invention to provide an improved method of forming solder bumps for microelectronic device connections, and improved solder bumps formed thereby.

It is another object of the present invention to provide a method of preserving the base of solder bumbs during their formation.

It is yet another object of the present invention to

reduce undercutting of the solder bump base during formation.

It is still another object of the present invention to reduce misalignment between the solder bump and the underlying contact pad.

According to the present invention, there is provided a method as claimed in claim 1, and a device as claimed in claim 15.

The solder pads are reflowed or melted prior to etching the under-bump metallurgy between the solder pads. An intermetallic layer of the under-bump metallurgy and the solder is thus formed between the solder bump and the contact pad, at the base of the solder bump, prior to etching the under-bump metallurgy. Accordingly, at least part of the under-bump metallurgy layer between the solder bump and contact pad is converted to an intermetallic of the solder and the under-bump metallurgy, prior to etching the under-bump metallurgy. Preferably, when the under-bump metallurgy includes a top layer of copper, and lead-tin solder is used, substantially all of the top copper, and lead-tin solder is used, substantially all of the top copper layer is converted to an intermetallic of copper and tin.

The intermetallic layer is resistant to etchants which are used to etch the under-bump metallurgy. The under-bump metallurgy may therefore be removed between the contact pads, while preserving the intermetallic layer at the base of the solder bump. Accordingly, minimal undercutting of the solder bumps is produced so that the base size is preserved and the contact pads are not exposed. Electrical and mechanical reliability of the solder bump connection is thereby enhanced.

The invention also reduces misalignment between the solder pads and its underlying contact pads, and tolerates distortion in patterning the solder accumulation layer. In particular, a continuous under-bump metallurgy is formed on the contact pads and on the microelectronic substrate between the contact pads. Solder dams are then formed on the under-bump metallurgy between the contact pads such that the solder dams expose the under-bump metallurgy over the contact pads. The exposed under-bump metallurgy over the contact pads define the location of the solder bump base. During reflow, the solder will retract or spread to these areas.

The solder dams, also referred to as solder stops, are preferably formed from a thin film layer (on the order of 1 micrometer or less) such as a thin film of chromium (on the order of 1500Å (1μm = 10^4 Å) thick), which adheres well to the under-bump metallurgy. The solder dams are precisely aligned to the underlying contact pads using known integrated circuit photolithography. The solder dams are preferably patterned using a lift-off technique, although other photolithographic techniques may be used to pattern the solder dams.

Solder retaining walls are then formed on the solder dams. These walls, which may be formed of thick film (on the order of 50 micrometers) photoresist, need only accumulate solder volume. They need not be used for alignment purposes, because the solder dams provide precise alignment. Accordingly, misalignment and distortion of the thick film solder retaining walls will not reduce the base of the solder bump over the contact pads. Solder pads are then electroplated onto the substrate over the contact pads, on the areas of the under-bump metallurgy which are exposed by the solder dams and solder retaining walls. The solder retaining walls may then be removed.

Then, prior to removing the under-bump metallurgy between the contact pads, the solder is reflowed (melted) to form a solder bump having an intermetallic layer of the solder and the under-bump metallurgy at the base of the solder bump adjacent the contact pad. For example, when the topmost component of the under-bump metallurgy is copper and conventional lead/tin solder is used, a copper/tin intermetallic is typically formed. During reflow, the solder dams prevent lateral spread and bridging of the solder, and control the size of the bump base.

The solder dams and under-bump metallurgy are then etched to isolate the solder bumps, using at least one etchant which etches the intermetallic layer more slowly than the solder bumps and under-bump metallurgy. Since the intermetallic has been formed at the base of the solder bumps, the bumps are relatively unaffected by the etchant. In particular, a mixture of ammonium hydroxide with trace amounts of hydrogen peroxide may be used to etch copper, and a hydrochloric acid based etchant may be used to etch chromium. Neither of these etchants is effective against the copper/tin intermetallic.

The base of the solder bumps formed according to the present invention is not reduced by under-bump metallurgy etching or solder pad misalignment/distortion. By preserving the base geometry, mechanical and electrical reliability is enhanced.

Moreover, it has been found that there is a lateral reaction between the solder pad and the under-bump metallurgy during the reflow step of the present invention. Accordingly, the intermetallic layer formed at the base of each solder bump extends beyond the bump to form a lip around the base of the solder bump. This lip provides extra protection for the edge of the solder bump and the edge of the contact pad underneath the solder bump. Accordingly, the invention produces a new profile of solder bump, which improves mechanical and electrical reliability.

Reference will now be made to the accompanying drawings, in which:-

Figures 1-5 illustrate cross-sectional views of a microelectronic substrate during fabrication of solder bumps thereon according to the present invention; and

Figure 6 is a scanning electron microscope photograph of a solder bump formed according to the present invention.

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which a preferred embodiment of the invention is shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiment set forth herein; rather, this embodiment is provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring now to Figure 1, there is illustrated a microelectronic substrate 10 having a plurality of contact pads 12 thereon. It will be understood by those having skill in the art that microelectronic substrate 10 may be an integrated circuit chip, a circuit board or microelectronic package substrate, or any other substrate which requires electrical and mechanical connection. Contact pads 12 are formed on substrate 10 using well known techniques which need not be described herein. The contact pads are typically aluminium for integrated circuit chips, although other metals and metal composites may also be used for integrated circuit chips and other substrates.

As also shown in Figure 1, a passivating dielectric **14** is formed on the substrate **10** and patterned to expose the contact pads **12,** using conventional plasma or reactive ion etching or other well known patterning techniques. A continuous under-bump metallurgy **16** is then formed on the substrate over the contact pads **12** and between the contact pads **12.** As is well known to those having skill in the art, the under-bump metallurgy **16** typically contains a (bottom) chromium layer (about 1000Å thick) adjacent substrate **10** and pads **12,** which functions as an adhesion layer and diffusion barrier for the under-bump metallurgy. A top copper layer (about 1 micrometer thick) is typically provided to act as a solderable metal, and a phased chromium/copper layer (about 1000Å thick) is formed between the chromium and copper layers. The under-bump metallurgy may be formed by conventional thin film deposition techniques such as evaporation or sputtering, and need not be described further herein.

Referring now to Figure 2, a solder dam or solder stop layer **18** is formed on the under-bump metallurgy layer **16** between the contact pads **10,** exposing the under-bump metallurgy layer over the pads **12.** Solder dam layer **18** is preferably a thin film, which does not wet with solder. Chromium or titanium solder dams on the order of 1500Å thick, may be used. Solder dam layer **18** is preferably formed by depositing a continuous solder dam layer **18** and patterning using lift-off or etch techniques. The thin film may be patterned with reduced misalignment and distortion, compared to thick film photoresist, by using integrated circuit photolithography, because of reduced light scattering, better adhesion and more precise developing. Improved alignment between the gaps in solder dam layer **18** where the solder bumps will be anchored, and the connector pads **12** thereunder, may be obtained by using a lift-off technique to remove the solder dam layer over pads **12.**

Referring now to Figure 3, solder retaining walls **28** are formed on solder dams **18.** These walls may be formed of thick film photoresist. Since the solder retaining walls are used to accumulate solder volume, and need not be used for alignment relative to contact pads **12,** their imprecise alignment and distorted shape will not reduce the base of the solder bumps.

Still referring to Figure 3, solder pads **20** are then formed on substrate **10,** typically by electroplating. Volume is acquired by filling the spaces between the solder retaining walls **28** during plating. The solder pads **20** may be confined within the gaps in the solder dam layer **18** or may be allowed to extend over the solder dams, as is illustrated in Figure 3. The solder retaining walls **28** may then be removed.

Referring now to Figure 4, solder pads **20** are reflowed prior to removing the under-bump metallurgy layer **16** between the contact pads **12,** to form an intermetallic layer **22** at the base of each solder bump **24.** When the topmost component of the under-bump metallurgy layer is copper (about 1 micrometer thick) and conventional lead-tin solder (5 weight percent tin) is used, the intermetallic **22** which forms is Cu3Sn. It will be understood by those having skill in the art that a thin layer of the under-bump metallurgy **16,** typically the bottom chromium layer and the phased chromium-copper layer (not shown in Figure 4) may remain on contact pad **12** between the intermetallic layer **22** and contact pad **12.**

In order to ensure almost complete conversion of the copper in the top layer of the under-bump metallurgy to the copper/tin intermetallic, reflow preferably takes place for 1-2 minutes above the melting point of the solder. The unconverted copper in the phased chromium-copper region prevents detachment of the solder bumps from the chromium adhesion layer, and thereby enhances structural integrity. During reflow, solder dams **18** prevent lateral spread and bridging of the solder and thereby control the size of the solder bump base. Reflow may be performed in air or in an inert ambient such as nitrogen, typically with flux applied, or in a reducing ambient such as hydrogen, without flux. As is well known to those having skill in the art, flux residues, if present, should be cleaned prior to etching the solder dam **18** and the under-bump metallurgy **16.**

As also shown in Figure 4, there is a lateral reaction between the solder **20** and the under-bump metallurgy **16** during reflow. Accordingly, the intermetallic layer formed underneath each bump includes a lip or ridge **26** which typically extends several micrometers from the bump. This lip or ridge may be used to identify solder bumps formed according to the present invention, because lateral reaction with the under-bump metallurgy cannot take place if all under-bump metallurgy between the contact pads is removed prior to reflow. This lip or ridge **26** also provides an added degree of protection for the base of the solder bump. An improved performance

solder bump is thereby provided.

Referring now to Figure 5, the solder dam **18** and the under-bump metallurgy **16** between the contact pads **12** are removed, while preserving the base of the reflowed solder bumps **24.** Since the top copper layer of the under-bump metallurgy between solder bump **24** and contact pad **12** has been converted into an intermetallic layer, the solder dams and the remaining under-bump metallurgy between contact pads **12** may be removed, without substantially removing the intermetallic. An etchant or etchants are used which etch the intermetallic **22** much more slowly than solder dam **18** and under-bump metallurgy **16.** Preferably, the etchants do not etch the under-bump metallurgy **16** while removing solder dams **18** and intermetallic **22.**

For example, for chromium solder dams **18,** a hydrochloric acid based etchant such as Transene CRE473 is an effective etchant, and a mixture of ammonium hydroxide and a trace amount of hydrogen peroxide is an effective copper etchant. Contact to the metal surface in the substrate with a zinc rod may be required to initiate etching of chromium. When titanium is used as a solder dam, a mixture of ammonium hydroxide and hydrogen peroxide (typically higher peroxide concentrations than in the copper etchant) is effective. Multiple etch cycles may be needed to remove the phased chromium copper layer and the bottom chromium layer. Neither of these etchants is effective against the copper/tin intermetallic and neither of these etchants attacks solder to a detectable extent. It will be understood by those having skill in the art that during copper etching, the device may be left in the etchant for as long as necessary to completely remove the copper between the bumps. It will also be understood by those having skill in the art that other etchants may be used, and other removal processes may be used.

Accordingly, an improved solder bump fabrication process is provided. Imperfections in photolithographic processing of thick film photoresists also do not degrade alignment. Moreover, undercutting of the solder bump base during under-bump metallurgy etching is substantially reduced or eliminated. The base geometry of the solder bump is therefore preserved. In fact, the process preferably forms a lip at the base of the solder bump to further protect the solder bump, and enhance electrical and mechanical reliability. Figure 6 is a scanning electron microscope photograph of a solder bump formed according to the present invention, illustrating solder bump **24,** lip **26** and substrate **10.**

It will be understood by those having skill in the art that reduced bump base undercutting may be obtained with the present invention, independent of misalignment/distortion reduction, by reflowing the solder prior to removing the under-bump metallurgy between the contact pads. For example, in some microelectronic substrate designs, the designed bump base may be substantially larger than the contact pads, so that alignment of the solder bump to the contact pads is relatively unimportant. Misalignment -or distortion of the solder bump relative to the contact pads may be tolerated.

A simplified process which allows misalignment or distortion between the solder bump and the contact pads will now be described. The under-bump metallurgy may contain the same bottom chromium layer, phased chromium/copper layer and top copper layer described above. However, a second chromium layer is added on the top copper layer. Solder retaining walls made, for example, of thick film photoresist, are formed and patterned as described above. The patterned solder dam layer described above is not formed.

The second chromium layer is then removed in the cavities between the solder retaining walls, and solder is plated as already described. After removing the solder retaining walls, the solder is reflowed to form an intermetallic and protect the bump base as already described. The second chromium layer between the contact pads prevents the reflowed solder from bridging. The second chromium layer may be misaligned relative to the contact pads, but this misalignment may be relatively unimportant in view of the substrate design. The base of the solder bump is still protected during etching of the under-bump metallurgy by reflowing prior to removing the under-bump metallurgy between the contact pads.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

Claims

1. A method of forming solder bumps **(24)** on a plurality of contact pads **(12)** on a substrate **(10)**, comprising the steps of:

   forming an under-bump metallurgy **(16)** on said contact pads **(12)** and on said substrate **(10)** between said contact pads **(12)**; then
   forming thick film solder retaining walls **(28)** on said substrate **(10)** between said contact pads **(12)**, said solder retaining walls **(28)** exposing said under-bump metallurgy **(16)** over said contact pads **(12)** then
   forming solder pads **(20)** over said contact pads **(12)**, on the under-bump metallurgy **(16)** which is exposed by said solder retaining walls **(28)**; then
   reflowing the solder pads **(20)** to form solder bumps **(24)** having an intermetallic layer **(22)** of said under-bump metallurgy **(16)** extending adjacent to said contact pads **(12)**; and then
   etching said under-bump metallurgy **(16)** between said contact pads **(12)**; the method being

characterized by:

adding the step of forming thin film solder dams (18) on said under-bump metallurgy (16) between said contact pads (12) prior to the step of forming solder retaining walls, said solder dams (18) exposing said under-bump metallurgy (16) over said contact pads (12) and said retaining walls (28) being formed on said solder dams (18); and

replacing said etching step with the step of etching said solder dams (18) and said under-bump metallurgy (16) between said contact pads, with at least one etchant which etches said intermetallic layer (22) more slowly than said solder dams (18) and said under-bump metallurgy (16), to said solder bumps (24) adjacent said contact pads (12).

2. The method of claim 1 wherein said forming an under-bump metallurgy step is preceded by the step of forming a passivating layer (14) on said substrate, between said contact pads.

3. The method of claim 1 wherein said forming an under-bump metallurgy step comprises the step of forming an under-bump metallurgy (16) having a chromium layer adjacent said substrate (10) and said contact pads (12), an intermediate chromium/copper phased layer on said chromium layer, and a copper layer on said chromium/copper layer.

4. The method of claim 1 wherein said forming thin film solder dams step comprises the steps of:

forming a thin film solder dam layer (18) on said substrate (10), between and over said contact pads (12); and

removing said thin film solder dam layer (18) over said contact pads (12).

5. The method of claim 4 wherein said removing step comprises the step of lifting-off said solder dam layer (18) over said contact pads (12).

6. The method of claim 1 wherein said solder depositing step comprises the step of plating solder (20) over said contact pads (12), on the under-bump metallurgy (16) which is exposed by said solder dams (18) and said solder retaining walls (28).

7. The method of claim 1 wherein said reflowing step comprises the step of melting said solder pads (20).

8. The method of claim 1 wherein said reflowing step further comprises the step of reflowing the solder pads (20) to form a lip (26) in said intermetallic layer (22).

9. The method of claim 1 wherein said solder (20), (24) comprises lead/tin solder, wherein said under-bump metallurgy (16) includes copper, and wherein said reflowing step comprises the step of reflowing the solder pads (20) to form solder bumps (24) having an intermetallic layer (22) of copper and tin.

10. The method of claim 1 wherein said forming solder pads step comprises the step of plating solder (20) on the under-bump metallurgy (16) on said contact pads (12).

11. The method of claim 1 wherein said forming solder pads step comprises the step of forming solder (20) on the under-bump metallurgy (16) on said contact pads (12), while restricting formation of solder between said contact pads (12).

12. The method of claim 1 wherein said reflowing step further comprises the step of forming a lip (26) in said intermetallic layer (22) during reflow.

13. The method of claim 11 wherein said forming solder pads step comprises the steps of:

forming solder retaining walls (28) on said under-bump metallurgy (16) between said contact pads (12), said solder retaining walls (28) exposing said under-bump metallurgy (16) over said contact pads (12); then

forming solder (20) on the under-bump metallurgy over said contact pads (12), with said solder retaining walls (28) restricting formation of solder (20) between said contact pads (12).

14. The method of claim 3 wherein said forming an under-bump metallurgy step further comprises the step of forming a second chromium layer on said copper layer; and wherein said forming solder pads step comprises the steps of:

forming solder retaining walls (28) on said under-bump metallurgy (16) between said contact pads (12), said solder retaining walls (28) exposing said under-bump metallurgy (16) over said contact pads (12); then

removing said second chromium layer over said contact pads (12); and then

forming solder (20) on said under-bump metallurgy (16) over said contact pads (12), with said solder retaining walls (28) restricting formation of solder (20) between said contact pads (12).

15. An interconnection system for a microelectronic substrate (10) comprising:

a plurality of contact pads (12) on said substrate (10);

a spheroidal solder bump (**24**) on each of said contact pads (**12**) having a base on said contact pad (**12**); and
a circular lip (**26**) on said spheroidal solder bump (**24**) at the base thereof, extending outwardly from said solder bump (**24**) over the associated contact pad (**12**), to thereby protect the contact pad (**12**).

16. The interconnection system of claim 15 wherein said spheroidal solder bump (**24**) is a spheroidal lead-tin solder bump and wherein said circular lip (**26**) is a copper/tin intermetallic circular lip.

17. The interconnection system of claim 15 wherein said circular lip (**26**) extends outwardly a few microns from said solder bump (**24**).

Patentansprüche

1. Verfahren zum Ausbilden von Löthöckern (24) auf einer Vielzahl von Kontaktflächen (12) auf einem Substrat (10), das die Schritte umfaßt:

   Ausbilden einer Metallurgie (16) unter den Hökkern auf den Kontaktflächen (12) und auf dem Substrat (10) zwischen den Kontaktflächen (12), dann
   Ausbilden von Rückhaltewänden (28) für das Lot aus dickem Film auf dem Substrat (10) zwischen den Kontaktflächen (12), wobei Rückhaltewände (28) für das Lot die Metallurgie (16) unter den Höckern über den Kontaktflächen (12) freilegen, dann
   Ausbilden von Lotauflagen (20) über den Kontaktflächen (12) auf der Metallurgie (16) unter den Höckern, die durch die Rückhaltewände (28) für das Lot freigelegt ist, dann
   Wiederverflüssigen der Lotauflagen (20), um Löthöcker (24) mit einer intermetallischen Schicht (22) aus der Metallurgie (16) unter dem Höcker auszubilden, die sich angrenzend an die Kontaktflächen (12) erstreckt, und dann
   Ätzen der Metallurgie (16) unter den Höckern zwischen den Kontaktflächen (12), gekennzeichnet durch:
   Hinzufügen des Schrittes des Ausbildens von Lotdämmen (18) aus dünnem Film auf der Metallurgie (16) unter den Höckern zwischen den Kontaktflächen (12) vor dem Schritt des Ausbildens von Rückhaltewänden für das Lot, wobei die Lotdämme (18) die Metallurgie (16) unter den Höckern über den Kontaktflächen (12) freilegen und die Rückhaltewände (28) auf den Lotdämmen (18) ausgebildet werden, und
   Ersetzen des Ätzschritts durch den Schritt des Ätzens der Lotdämme (18) und der Metallurgie (16) unter den Höckern zwischen den Kontaktflächen mit wenigstens einer Ätzflüssigkeit, die die intermetallische Schicht (22) langsamer als die Lotdämme (18) und die Metallurgie (16) unter den Höckern ätzt, zu den an die Kontaktflächen (12) angrenzenden Löthöckern (24).

2. Verfahren nach Anspruch 1, bei dem dem Schritt des Ausbildens einer Metallurgie unter den Hökkern der Schritt des Ausbildens einer passivierenden Schicht (14) auf dem Substrat zwischen den Kontaktflächen vorausgeht.

3. Verfahren nach Anspruch 1, bei dem der Schritt des Ausbildens einer Metallurgie unter den Höckern den Schritt des Ausbildens einer Metallurgie (16) unter den Höckern mit einer an das Substrat (10) und die Kontaktflächen (12) angrenzenden Chromschicht, einer abgestimmten Zwischenschicht aus Chrom/Kupfer und einer Kupferschicht auf der Chrom/Kupfer-Schicht umfaßt.

4. Verfahren nach Anspruch 1, bei dem der Schritt des Ausbildens von Lotdämmen aus dünnem Film die Schritte umfaßt:

   Ausbilden einer Schicht (18) für die Lotdämme aus dünnem Film auf dem Substrat (10) zwischen und über den Kontaktflächen (12) und
   Entfernen der Schicht (18) für die Lotdämme aus dünnem Film über den Kontaktflächen (12).

5. Verfahren nach Anspruch 4, bei dem der Schritt des Entfernens den Schritt des Abhebens der Schicht (18) für die Lotdämme über den Kontaktflächen (12) umfaßt.

6. Verfahren nach Anspruch 1, bei dem der Schritt zum Aufbringen des Lots den Schritt des Plattierens von Lot (20) über den Kontaktflächen (12) auf die Metallurgie (16) unter den Höckern, die von den Lotdämmen (18) und den Rückhaltewänden (28) für das Lot freigelegt ist.

7. Verfahren nach Anspruch 1, bei dem der Schritt des Wiederverflüssigens den Schritt des Schmelzens der Lotauflagen (20) umfaßt.

8. Verfahren nach Anspruch 1, bei dem der Schritt des Wiederverflüssigens des weiteren den Schritt des Wiederverflüssigens der Lotauflagen (20) umfaßt, um eine Lippe (26) in der intermetallischen Schicht (22) auszubilden.

9. Verfahren nach Anspruch 1, bei dem das Lot (20), (24) Blei/Zinn--Lot umfaßt, die Metallurgie (16) unter den Höckern Kupfer beinhaltet und der Schritt

des Wiederverflüssigens den Schritt des Wiederverflüssigens der Lotauflagen (20) umfaßt, um Löthöcker (24) mit einer intermetallischen Schicht (22) aus Kupfer und Zinn auszubilden.

10. Verfahren nach Anspruch 1, bei dem der Schritt des Ausbildens von Lotauflagen den Schritt des Plattierens von Lot (20) auf die Metallurgie (16) unter den Höckern auf den Kontaktflächen (12) umfaßt.

11. Verfahren nach Anspruch 1, bei dem der Schritt des Ausbildens der Lotauflagen den Schritt des Ausbildens des Lots (20) auf der Metallurgie (16) unter den Höckern auf den Kontaktflächen (12) umfaßt, während die Ausbildung von Lot zwischen den Kontaktflächen (12) eingeschränkt ist.

12. Verfahren nach Anspruch 1, bei dem der Schritt des Wiederverflüssigens des weiteren den Schritt des Ausbildens einer Lippe (26) in der intermetallischen Schicht (22) während des Wiederverflüssigens umfaßt.

13. Verfahren nach Anspruch 11, bei dem der Schritt des Ausbildens der Lotauflagen die Schritte umfaßt:

   Ausbilden von Rückhaltewänden (28) für das Lot auf der Metallurgie (16) unter den Höckern zwischen den Kontaktflächen (12), wobei die Rückhaltewände (28) für das Lot die Metallurgie (16) unter den Höckern über den Kontaktflächen (12) freilegen, dann
   Ausbilden von Lot (20) auf der Metallurgie unter den Höckern über den Kontaktflächen (12), wobei die Rückhaltewände (28) für das Lot die Ausbildung von Lot (20) zwischen den Kontaktflächen (12) einschränkt.

14. Verfahren nach Anspruch 3, bei dem der Schritt des Ausbildens einer Metallurgie unter den Höckern des weiteren den Schritt des Ausbildens einer zweiten Chromschicht auf der Kupferschicht umfaßt und der Schritt zum Ausbilden der Lotauflagen die Schritte umfaßt:

   Ausbilden von Rückhaltewänden (28) für das Lot auf der Metallurgie (16) unter den Höckern zwischen den Kontaktflächen (12), wobei die Rückhaltewände (28) für das Lot die Metallurgie (16) unter den Höckern über den Kontaktflächen (12) freilegen, dann
   Entfernen der zweiten Chromschicht über den Kontaktflächen (12) und dann
   Ausbilden von Lot (20) auf der Metallurgie (16) unter den Höckern über den Kontaktflächen (12), wobei die Rückhaltewände (28) für das Lot die Ausbildung von Lot (20) zwischen den Kontaktflächen (12) einschränken.

15. Verbindungssystem für ein Mikroelektroniksubstrat (10), welches umfaßt:

   eine Vielzahl von Kontaktflächen (12) auf dem Substrat (10),
   einen sphäroidischen Löthöcker (24) auf jeder der Kontaktflächen (12) mit einer Basis auf der Kontaktfläche (12) und
   eine kreisförmige Lippe (26) auf dem sphäroidischen Löthöcker (24) an dessen Basis, die sich vom Löthöcker (24) über die zugehörige Kontaktfläche (12) nach außen erstreckt, um dadurch die Kontaktfläche (12) zu schützen.

16. Verbindungssystem nach Anspruch 15, bei dem der sphäroidische Löthöcker (24) ein sphäroidischer Blei/Zinn-Löthöcker ist und die kreisförmige Lippe (26) eine intermetallische kreisförmige Lippe aus Kupfer/Zinn ist.

17. Verbindungssystem nach Anspruch 15, bei dem sich die kreisförmige Lippe (26) vom Löthöcker (24) einige Mikrometer nach außen erstreckt.

Revendications

1. Procédé de fabrication de perles de soudure (24) sur une pluralité de patins de contact (12) sur un substrat (10), comprenant les étapes de :

   former une métallurgie sous la perle (16) sur lesdits patins de contact (12) et sur ledit substrat (10) entre lesdits patins de contact (12) ; puis
   former des parois de retenue de soudure à film épais (28) sur ledit substrat (10) entre lesdits patins de contact (10), lesdites parois de retenue de soudure (28) exposant ladite métallurgie sous la perle (16) au-dessus desdits patins de contact (12) ; puis
   former des patins de soudure (20) au-dessus desdits patins de contact (12), sur la métallurgie sous la perle (16) qui est exposé par lesdites parois de retenue de soudure (28) ; puis
   souder par fusion les patins de soudure (20) pour former des perles de soudure (24) ayant une couche intermétallique (22) de ladite métallurgie sous la perle (16) s'étendant de manière adjacente auxdits patins de contact (12) ; et ensuite
   décaper ladite métallurgie sous la perle (16) entre lesdits patins de contact (12) ; le procédé étant caractérisé par le fait :
   d'ajouter l'étape de former des barrages de soudure à film mince (18) sur ladite métallurgie

sous la perle (16) entre lesdits patins de contact (12) avant l'étape de former des parois de retenue de soudure, lesdits barrages de soudure (18) exposant ladite métallurgie sous la perle (16) au-dessus desdits patins de contact (12), et lesdites parois de retenue (28) étant formées sur lesdits barrages de soudure (18) ; et

de remplacer ladite étape de décapage par l'étape de décaper lesdits barrages de soudure (18) et ladite métallurgie sous la perle (16) entre lesdits patins de contact, avec au moins un décapant qui décape ladite couche intermétallique (22) plus lentement que les barrages de soudure (18) et ladite métallurgie sous la perle (16), vers lesdites perles de soudure (24) adjacentes auxdits patins de contact (12).

2. Procédé selon la revendication 1, dans lequel ladite étape de former une métallurgie sous la perle est précédée par l'étape de former une couche passivante (14) sur ledit substrat, entre lesdits patins de contact.

3. Procédé selon la revendication 1, dans lequel ladite étape de former une métallurgie sous la perle comprend l'étape de former une métallurgie sous la perle (16) ayant une couche de chrome adjacente audit substrat (10) et auxdits patins de contact (12), une couche en phase intermédiaire chrome/cuivre sur ladite couche de chrome, et une couche de cuivre sur ladite couche de chrome/cuivre.

4. Procédé selon la revendication 1, dans lequel ladite étape de former des barrages de soudure à film mince comprend les étapes de :

   former une couche de barrage de soudure à film mince (18) sur ledit substrat (10), entre et au-dessus desdits patins de contact (12) ; et

   retirer ladite couche de barrage de soudure à film mince (18) au-dessus desdits patins de contact (12).

5. Procédé selon la revendication 4, dans lequel ladite étape de retirer comprend l'étape de soulever ladite couche de barrage de soudure (18) au-dessus desdits patins de contact (12).

6. Procédé selon la revendication 1, dans lequel ladite étape de déposer de la soudure comprend l'étape de plaquer de la soudure (20) au-dessus desdits patins de contact sur la métallurgie sous la perle (16) qui est exposée par lesdits barrages de soudure (18) et lesdites parois de soudure (28).

7. Procédé selon la revendication 1, dans lequel ladite étape de souder par fusion comprend l'étape de faire fondre lesdits patins de soudure (20).

8. Procédé selon la revendication 1, dans lequel ladite étape de souder par fusion comprend en outre l'étape de souder par fusion les patins de soudure (20) pour former une lèvre (26) dans ladite couche intermétallique (22).

9. Procédé selon la revendication 1, dans lequel ladite soudure (20, 24) comprend une soudure plomb/étain, dans lequel ladite métallurgie sous la perle (16) comprend du cuivre et dans lequel ladite étape de souder par fusion comprend l'étape de souder par fusion les patins de soudure (20) pour former des perles de soudure (24) ayant une couche intermétallique (22) de cuivre et d'étain.

10. Procédé selon la revendication 1, dans lequel ladite étape de former les patins de soudure comprend l'étape de plaquer de la soudure (20) sur ladite métallurgie sous la perle (16) sur lesdits patins de contact (12).

11. Procédé selon la revendication 1, dans lequel ladite étape de former des patins de soudure comprend l'étape de former une soudure (20) sur la métallurgie sous la perle (16) sur lesdits patins de contact (12), tout en empêchant une formation de soudure entre lesdits patins de contact (12).

12. Procédé selon la revendication 1, dans lequel ladite étape de souder par fusion comprend en outre l'étape de former une lèvre (26) dans ladite couche intermétallique (22) pendant le soudage par fusion.

13. Procédé selon la revendication 11, dans lequel ladite étape de former des patins de soudure comprend les étapes de :

   former des parois de retenue de soudure (28) sur ladite métallurgie sous la perle (16) entre lesdits patins de contact (12), lesdites parois de retenue de soudure (28) exposant ladite métallurgie sous la perle (16) au-dessus desdits patins de contact (12) ; puis

   former une soudure (20) sur la métallurgie sous la perle (16) au-dessus desdits patins de contact (12), avec lesdites parois de retenue de soudure (28) empêchant la formation de soudure (20) entre lesdits patins de contact (12).

14. Procédé selon la revendication 3, dans lequel ladite étape de former une métallurgie sous la perle comprend en outre l'étape de former une seconde couche de chrome sur ladite couche de cuivre ; et dans lequel ladite étape de former des patins de soudure comprend les étapes de :

   former des parois de retenue de soudure (28) sur ladite métallurgie sous la perle (16) entre

lesdits patins de contact (12), lesdites parois de retenue de soudure (28) exposant ladite métallurgie sous la perle (16) au-dessus desdits patins de contact (12) ; puis
retirer ladite seconde couche de chrome au-dessus desdits patins de contact (12) ; et puis
former une soudure (20) sur ladite métallurgie sous la perle (16) au-dessus desdits patins de contact (12), avec lesdites parois de retenue de soudure (28) empêchant la formation de soudure (20) entre lesdits patins de contact (12).

15. Système d'interconnexion pour un substrat microélectronique (10) comprenant :

une pluralité de patins de contact (12) sur ledit substrat (10) ;
une perle de soudure sphéroïdale (24) sur chacun des patins de contact (12) ayant une base sur ledit patin de contact (12) ; et
une lèvre circulaire (26) sur ladite perle de soudure sphéroïdale (24) à sa base, s'étendant vers l'extérieur à partir de ladite perle de soudure (24) au-dessus du patin de contact associé (12), pour ainsi protéger le patin de contact (12).

16. Système d'interconnexion selon la revendication 15, dans lequel ladite perle de soudure sphéroïdale (24) est une perle de soudure sphéroïdale plomb/étain, et dans lequel ladite lèvre circulaire (26) est une lèvre circulaire intermétallique cuivre/étain.

17. Système d'interconnexion selon la revendication 15, dans lequel ladite lèvre circulaire (26) s'étend vers l'extérieur de quelques microns à partir de ladite perle de soudure (24).

FIG. 1.

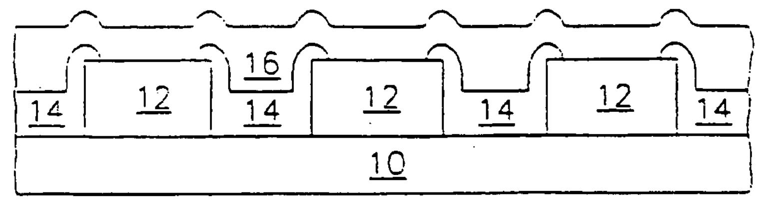


FIG. 2.

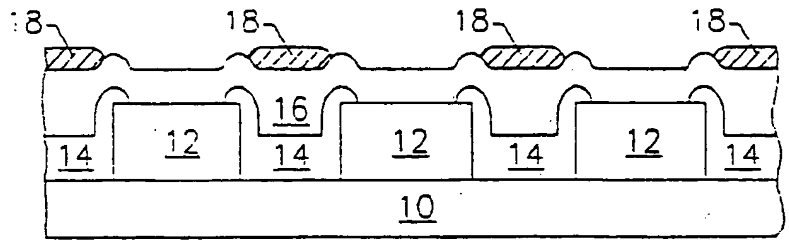


FIG. 3.

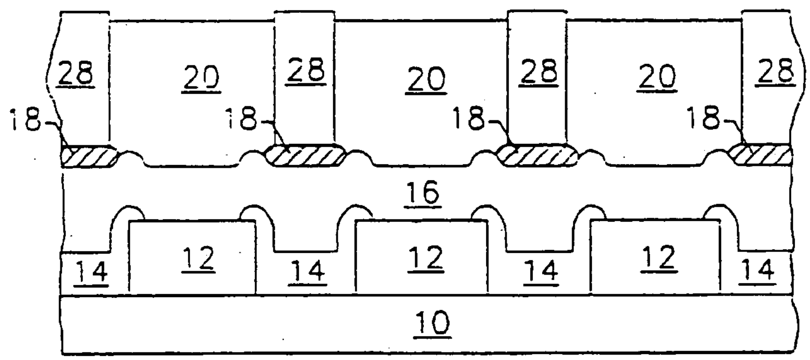


FIG. 4.

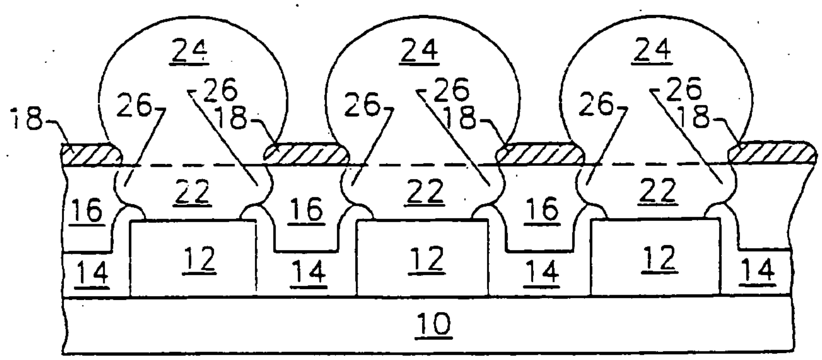
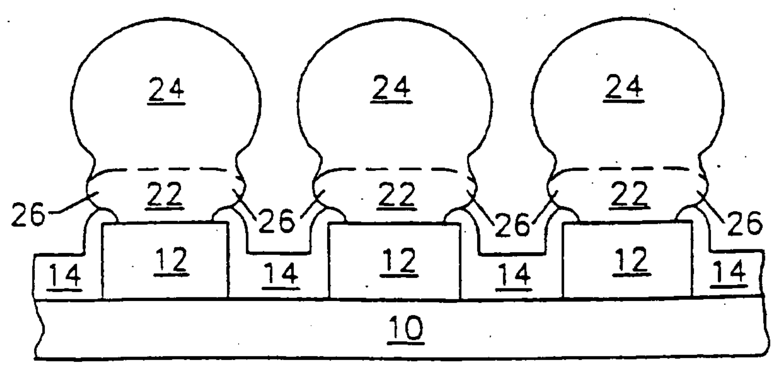


FIG. 5.



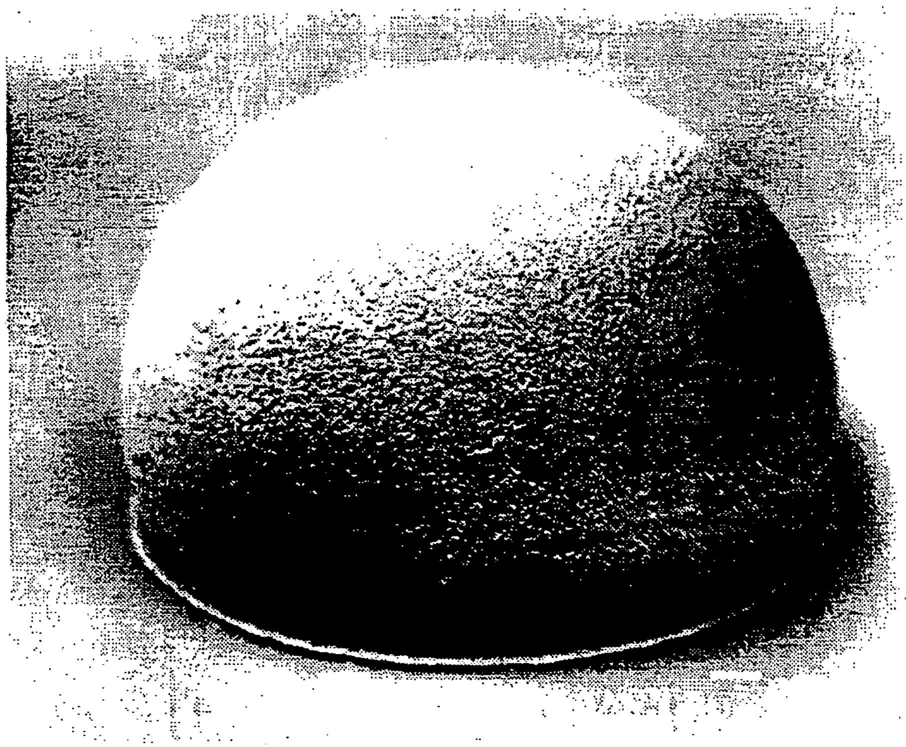


FIG. 6